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US 4856939 A

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INT CL[6] E02D

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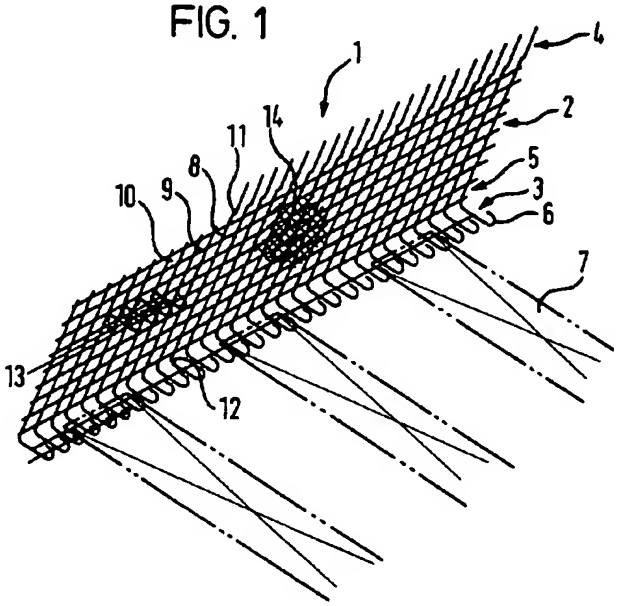
(54) Facing panel for earth structures

(57) A mesh facing panel 1 is provided for forming a facing of an earth structure stabilised by stabilising members 7 extending rearwardly from the facing into an earth mass. The mesh facing panel comprises a front portion 2, a base portion 3 arranged to extend rearwardly into the earth, and at least one hook 6 to which at least one said earth stabilising member 7 may be attached. In an upper or lower region thereof the panel 1 is formed with a crank 11 whereby upwardly extending bars 8 above and below the crank are offset and parallel.

FIG. 1



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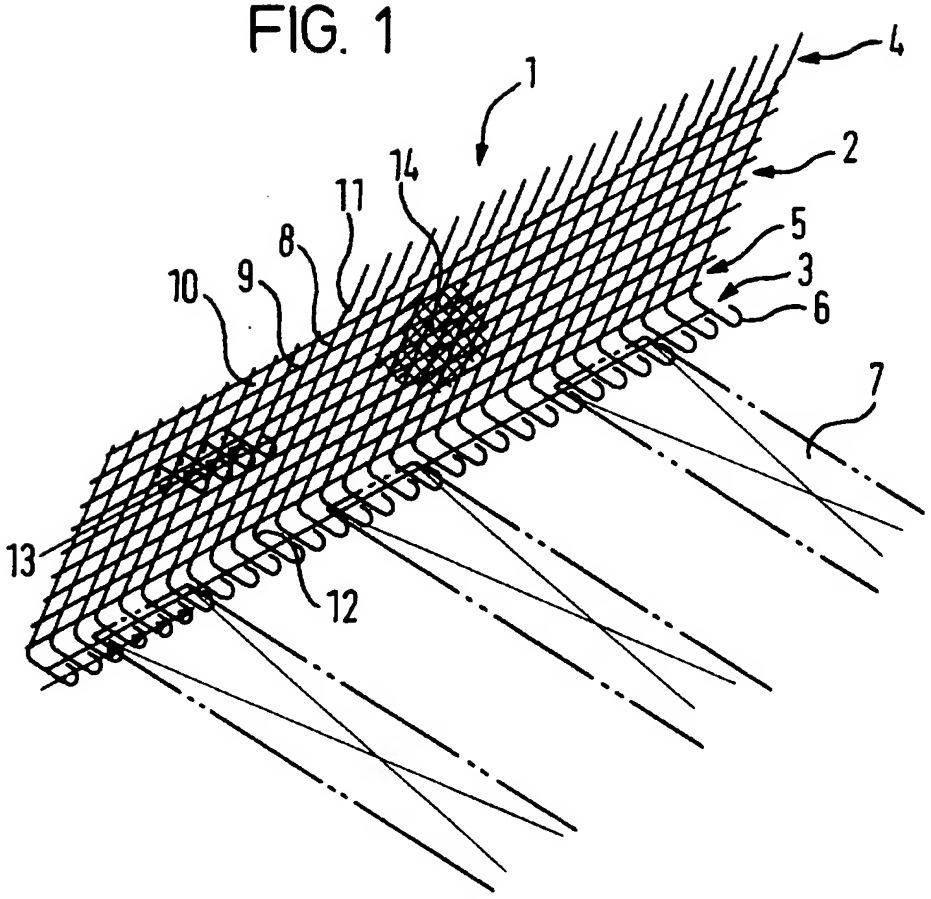
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG. 1



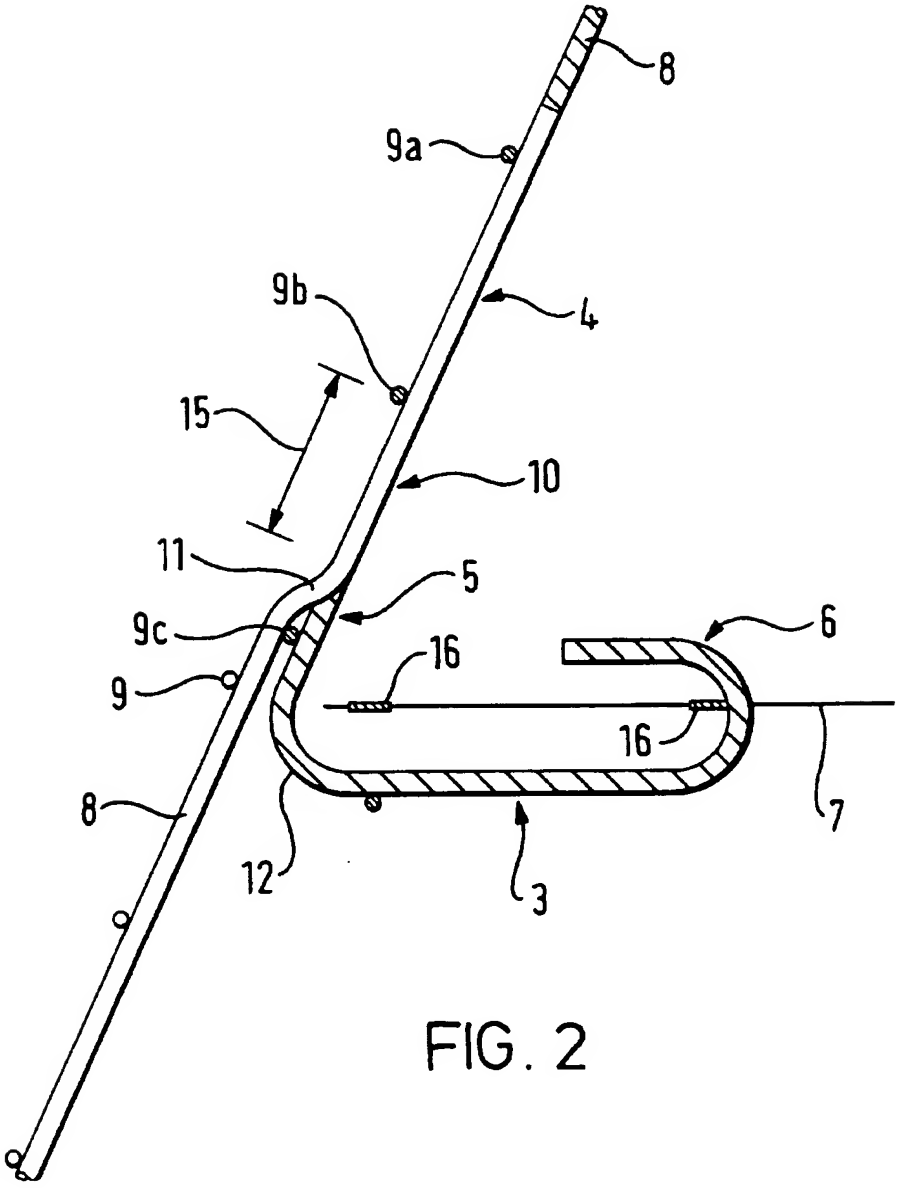


FIG. 2

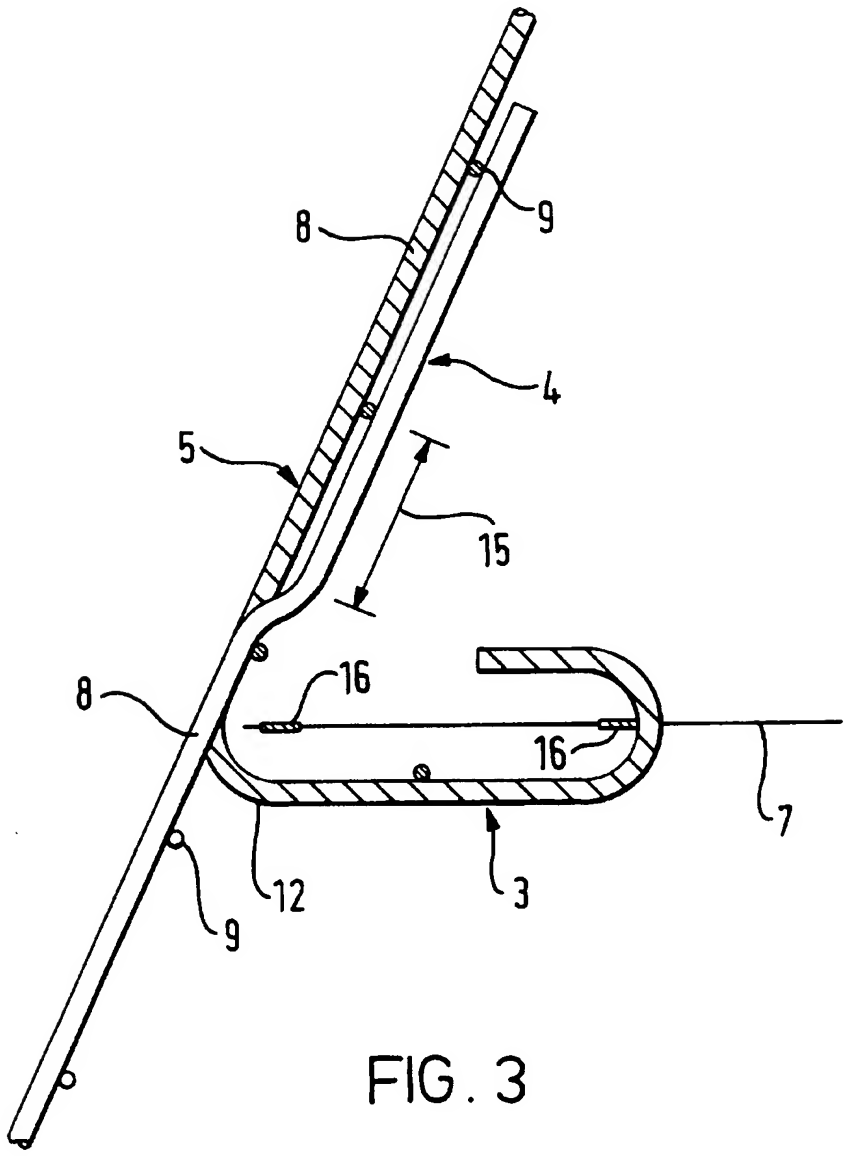


FIG. 3

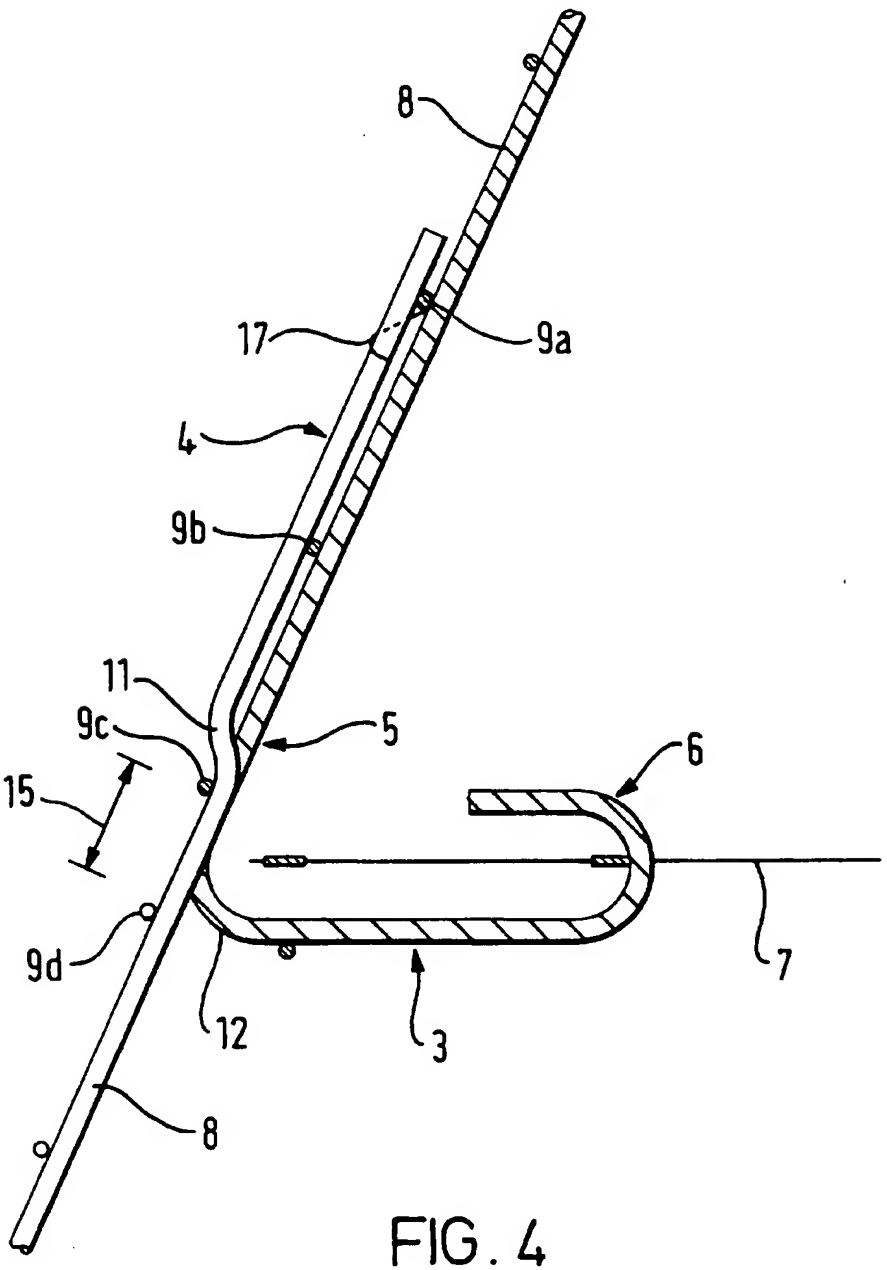


FIG. 4

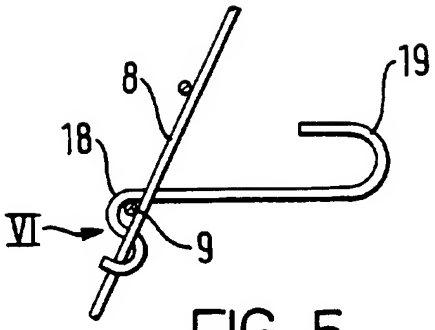


FIG. 5

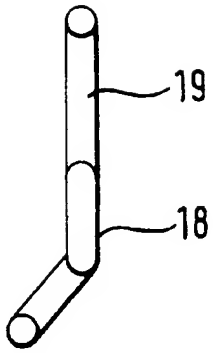


FIG. 6

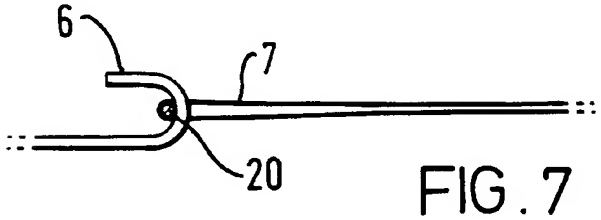


FIG. 7

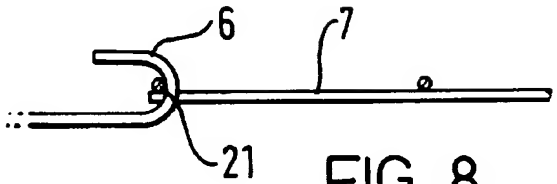


FIG. 8

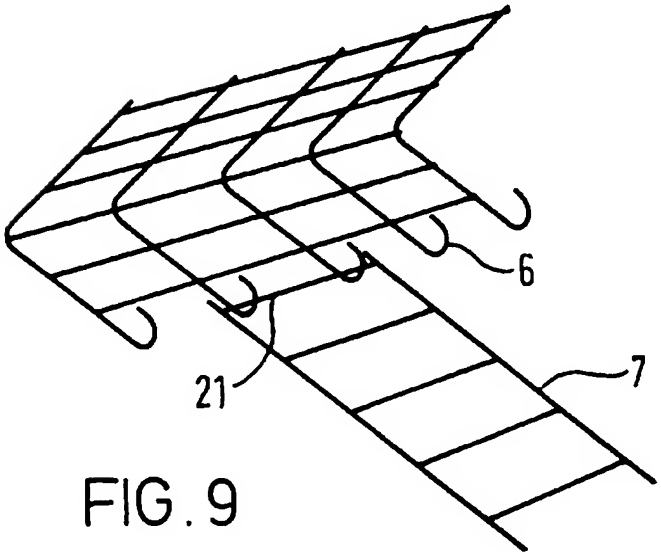


FIG. 9

FIG. 10

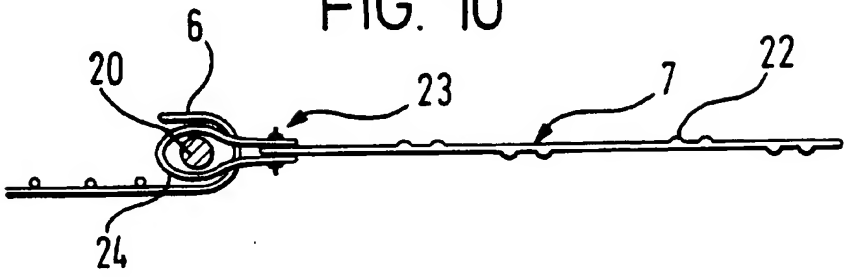


FIG. 11

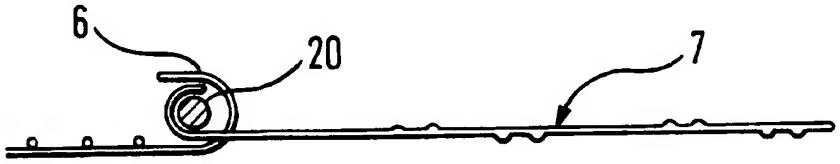


FIG. 12A

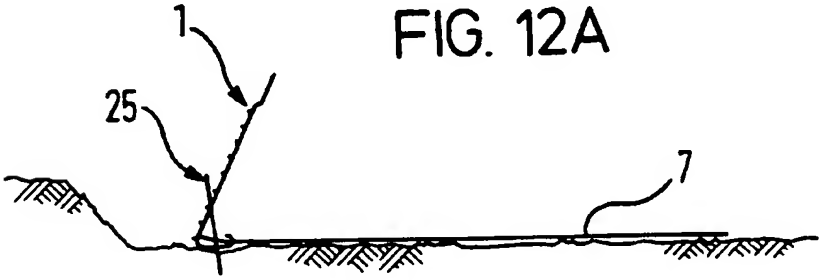


FIG. 12B

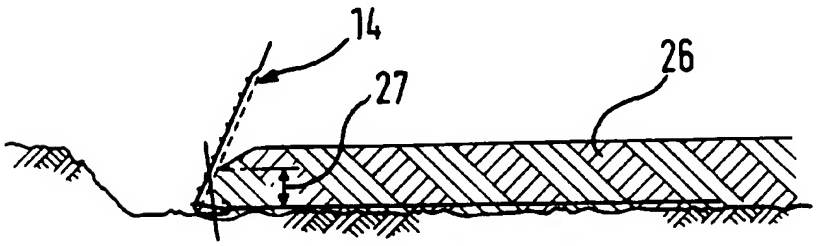


FIG. 12C

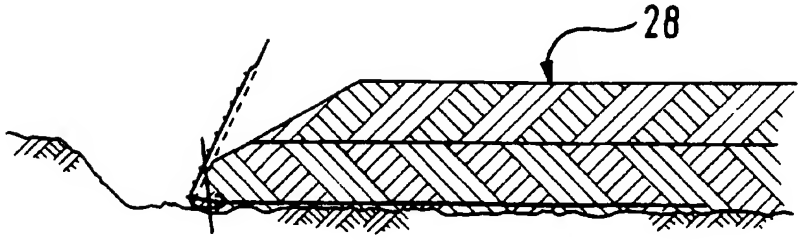


FIG. 12D

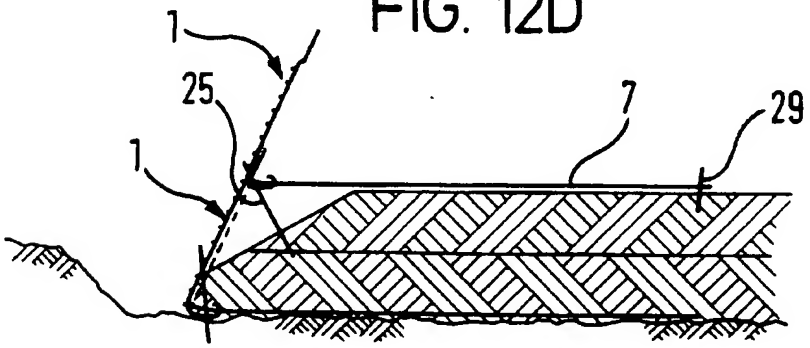


FIG. 12E

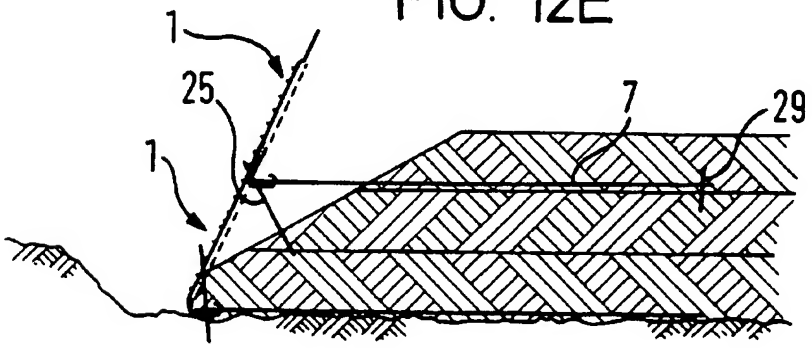


FIG. 12F

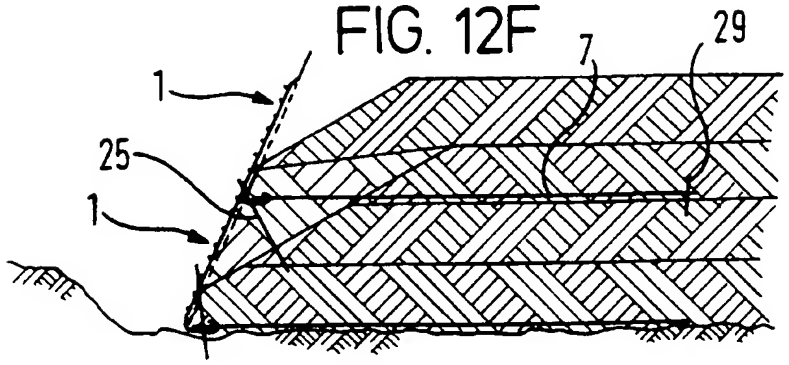


FIG. 12G

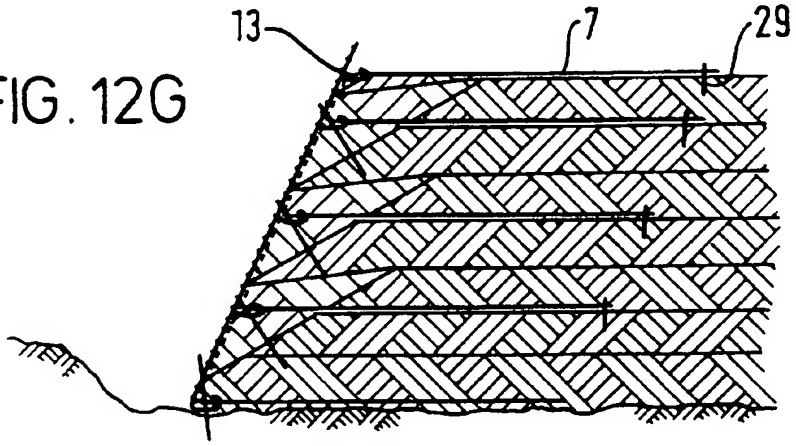


FIG. 12H

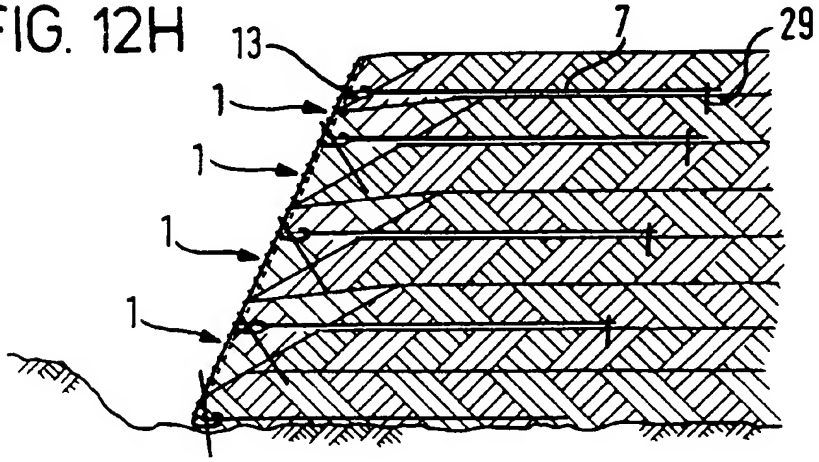


FIG.13

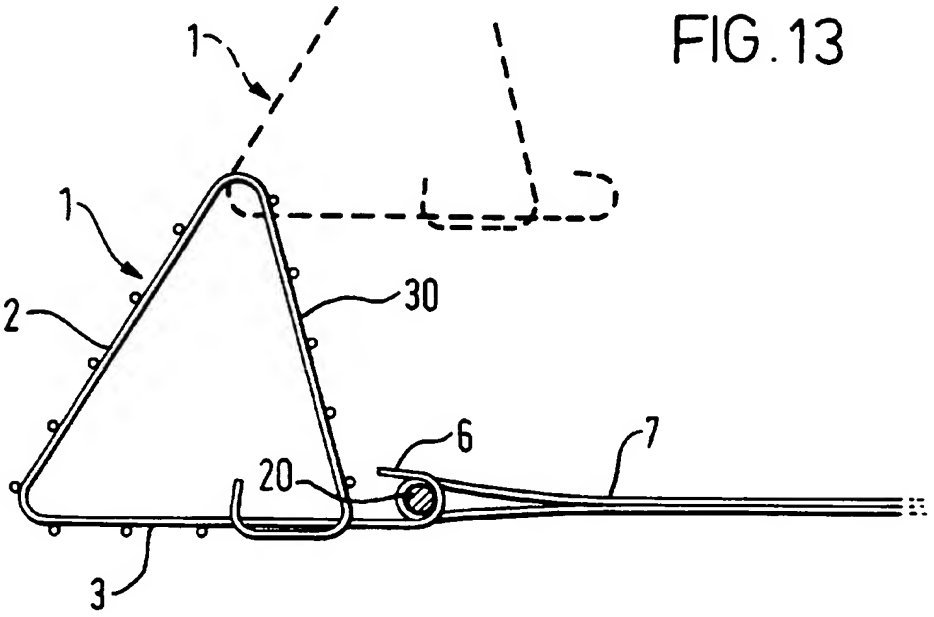
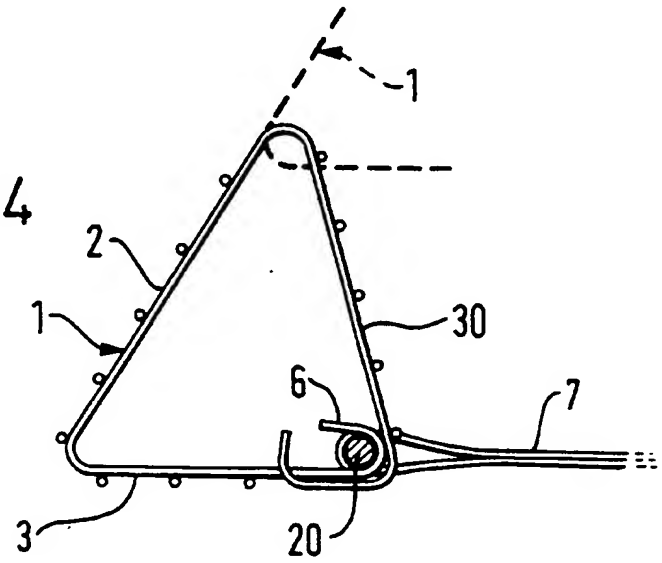


FIG.14



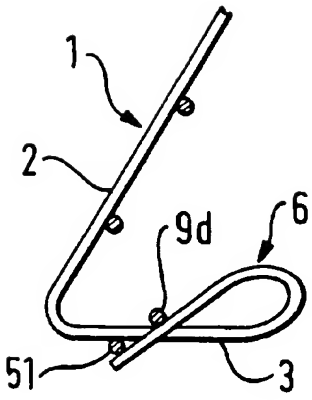


FIG.18

FIG. 15

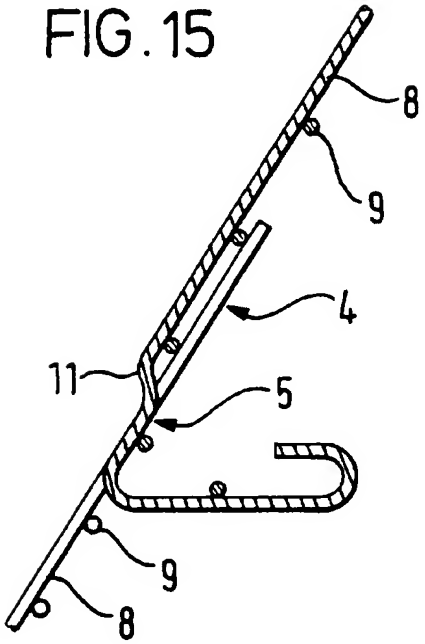


FIG. 16

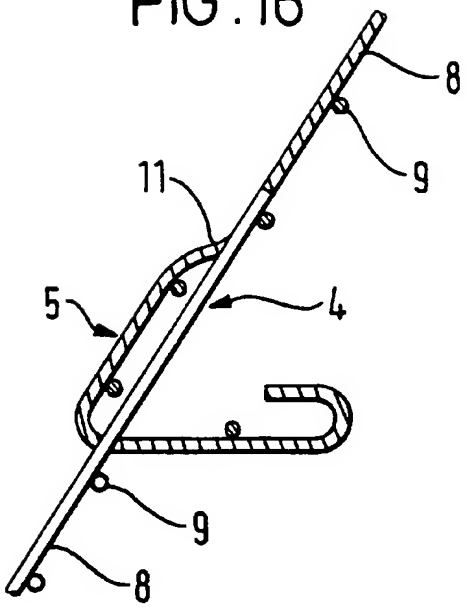
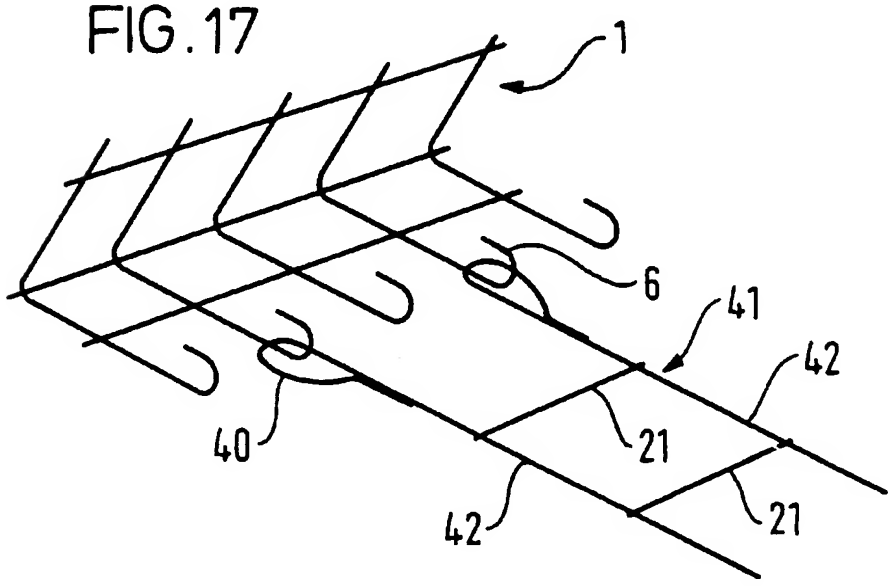


FIG. 17



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FACING PANEL FOR EARTH STRUCTURES

This invention is concerned with improvements in or relating to facing panels for forming a facing of an earth structure of the kind stabilised by stabilising members extending rearwardly from the facing into an earth mass.

In known structures vertically spaced layers of stabilising members are provided to stabilise the earth mass by frictional engagement therewith. This interaction enables the earth mass to behave as an cohesive material which greatly improves resistance to failure. The facing of such stabilised earth structures can be relatively light and has for example been built up from relatively thin concrete members. However, even such relatively lightweight panels can represent a major element of the cost of the structure.

An alternative form of facing involves the use of mesh facing panels, usually backed by a lining of geotextile material or the like to prevent erosion of earth through the facing. The facing can then be vegetated by means of planting or hydroseeding to produce growth of vegetation and, eventually, a facing which is "green".

It has been proposed in European Patent Application No. 0 197 000 to use steel mesh facing panels which are channel shaped, each having a front facing portion, a rearwardly extending base portion, and a rearwardly extending top portion. Each mesh panel is lined with geotextile material and is backfilled with earth up to the top portion. The earth behind the facing is stabilised by geotextile sheets each of which is located between the top portion of a panel and the base portion of a panel above. The weight of earth on the base

portion in the completed structure creates a connection between the geotextile sheets and the panels by compression. Careful supervision is required during laying of the sheets in the construction process to make sure that they are correctly positioned, extending up to the front of the facing to give an adequate connection by compression. Also, the facing system is generally only suitable for structures stabilised by sheets.

Viewed from a first aspect the invention provides a mesh facing panel for forming a facing of an earth structure stabilised by stabilising members extending rearwardly from the facing into an earth mass, the mesh facing panel comprising a front portion, a base portion arranged to extend rearwardly into the earth, and at least one hook to which at least one said earth stabilising member may be attached.

With such an arrangement, a positive attachment can be made between the panel and a stabilising member, by means of the hook. This helps to ensure proper positioning of the stabilising member in relation to the panel. In addition, the hook can be used for the attachment of a wide variety of types of stabilising member, such as sheets, grids or strips. Thus, a stock of panels can be used with different forms of stabilising member.

In general, the slope of a facing assembled from the panels can vary between 45° to the horizontal and 90° to the horizontal (i.e. vertical). The angle between the front and the base portions will preferably be the same as the angle of the facing to the horizontal, with the base portion arranged horizontally in use.

The hook is preferably provided at the rear of the panel. It is preferred for the hook to be formed by bending a portion of the panel, so as to be integral therewith.

The mesh facing panel may for example be of triangular cross-section, having a rear portion extending downwardly and rearwardly from the top of the front portion to the base portion. Providing the base portion is long enough the panel is self-supporting and during construction can simply be placed on a layer of earth backfill below. With such a triangular panel, the rear portion may be bent forwardly and, optionally, upwardly at its bottom end to form the at least one hook.

The mesh facing panel may alternatively be "L" shaped in cross-section, having the front portion and the base portion but no rear portion. In a preferred arrangement, the base portion is bent at its rear to form the at least one hook. This is possible for both triangular and "L" shaped panels. With the triangular panels, the hook may be provided inside or outside the triangle.

The end of the hook may be directed upwardly, the base portion being bent for example through 90° to form the hook. Preferably, however, the end of the hook is directed forwardly, the base portion being bent for example through 180° to form the hook. This can improve the security of the attachment of the stabilising member to the panel.

In some cases, for example high structures where significant tensile loads develop in the stabilising members and at their attachments to the facing, additional security may be provided by the base portion being bent through more than 180°. The end of the hook may be located above the rearwardly extending part of the base portion, or it may be located beneath the rearwardly extending part, preferably engaged beneath a laterally extending bar thereof. This lateral bar will then help to resist straightening of the hook under loading. Further, an additional laterally extending bar may be located, e.g. by welding, underneath the

rearwardly extending part and above the end of the hook. Such an additional bar would normally be installed after bending to form the hook.

The front portion of the mesh facing panel preferably has upwardly and laterally extending mesh bars, the upwardly extending bars being bent to form rearwardly extending bars of the base portion. It may be sufficient for just one of the base portion bars to be bent to form the hook, for example if the width of the panel corresponds to the lateral spacing of a plurality of stabilising members to be used in the structure. Preferably, however, more than one bar is bent to form a plurality of hooks. There may be individual hooks, or groups of hooks, at laterally spaced intervals across the panel, although it is preferred that substantially all the rearwardly extending base portion bars are bent to form hooks.

The invention extends to the combination of the mesh facing panel and at least one stabilising member attached thereto. In one form of the invention, the stabilising member is hooked directly on to the hook or hooks. This is possible when the stabilising member is a grid, mesh or net, in the form of a sheet or a wide strip and having openings through which hooks may be passed. For example, a wide strip of synthetic geogrid such as Tenax (trade mark) or a galvanised steel ladder-shaped strip may be used. Usually the mesh facing panel will be attached to a plurality of such strips disposed at lateral intervals. Another form of stabilising member which may be hooked directly on to a plurality of hooks comprises a geotextile sheet which can be perforated to receive the hooks. A still further form of stabilising member suitable for direct hooking comprises a galvanised steel strip, for example of the type known from GB-A-2 177 140, having a vertical hole in an end region which

may be inserted on a hook.

In another form of the invention the hook of the mesh facing panel extends in a vertical plane, and the stabilising member is formed at its forward end with a hook which extends in a horizontal plane, the hook of the panel and the hook of the stabilising member being engaged with each other. This provides a convenient connection arrangement. The hook of the stabilising member may be bent through 180° so as to have a rearwardly directed end portion. It is preferred for the hook to be in the form of a "loop", with its end portion disposed adjacent to a main rearwardly extending part of the stabilising member. The hook may be formed by a bent bar. In the preferred panel having laterally spaced hooks, the stabilising member has corresponding laterally spaced hooks engaged therewith. For example the stabilising member may comprise a pair of laterally spaced and longitudinally extending bars connected at longitudinal intervals by lateral bars, the longitudinal bars being provided at their forward ends with respective hooks.

In a further form of the invention, the stabilising member is attached to the hook via a laterally extending bar received by the hook. If for example the panel has just one hook, then the laterally extending bar may extend between the hooks of laterally adjacent panels. In the preferred panel having a plurality of hooks, the bar is received by those hooks. A stabilising member with sufficient deformability may then be looped round such a bar to provide two full length stabilising portions either lying on top of each other or splayed and arranged side by side. An example of such a stabilising member is a Websol (trade mark) strap or a Fortrac (trade mark) geogrid. Alternatively a galvanised steel strip may be bent

upwardly or downwardly at its forward end in order to hook on to the laterally extending bar. A further possibility is to provide a "U" shaped lug engaged on the bar with the legs of the "U" directed rearwardly and arranged to receive therebetween the forward end of a metal, e.g. galvanised steel, strip, and a bolt or pin passing through the legs and the strip forward end.

A facing will normally be built up from rows of mesh facing panels, each having at least one stabilising member attached to its base portion. It will generally be necessary additionally to anchor the front portion of each panel of the top row of the facing in order to restrain it from forward movement under earth pressure and maintain its alignment in the facing. This could for example be achieved by one or more tie bars extending from at or near the top of the panel down to the stabilising member or members buried in the earth below. However, since this tends to obstruct the backfilling of the top row of panels, it is preferred to attach at least one stabilising member to the front portion of each panel of the top row. A preferred panel is therefore provided with a hook connector to be mounted on the front portion thereof to extend rearwardly therefrom, the hook connector having at its front end means for connection with said front portion and at its rear end a hook for attachment of a said earth stabilising member. The connection means at the front of the hook connector may take various forms, but in a preferred embodiment it is a generally "S" shaped bar arranged to engage both an upwardly extending bar and a laterally extending bar of the panel. The hook at the rear of the hook connector may have the stabilising member attached thereto in the various ways described above in relation to the hook at the base of the panel.

When assembling the facing, it will normally be necessary to ensure that the front portion of each newly installed mesh facing panel is parallel to the front portion of the panel below. This can advantageously be achieved by the mesh facing panel having an upper region arranged to overlap in the assembled condition with a lower region of a mesh facing panel above, in such a way that the front portions of the mesh facing panels are substantially parallel. Thus, as each new mesh facing panel is installed, it is properly positioned relative to the one below. Such an arrangement is inventive in its own right.

Accordingly, viewed from a second aspect the invention provides a mesh facing panel for assembly with like mesh facing panels to form a facing of an earth structure stabilised by stabilising members extending rearwardly from the facing into an earth mass, the mesh facing panel comprising upwardly and laterally extending mesh bars which define mesh openings, and upper and lower regions, the upper region of the mesh facing panel being arranged to overlap in the assembled condition with the lower region of a mesh facing panel above, with the upwardly extending bars of one of said regions passing through a row of laterally adjacent mesh openings of the other said region, and the mesh facing panel being prefabricated, prior to assembly, such that in the assembled condition it is substantially parallel to the mesh facing panel above.

Again, with such an arrangement, the mesh facing panel above is properly positioned in the required parallel arrangement with the already installed panel. Because the upwardly extending bars of one of the panels pass through the mesh openings of the other panel, the parallel relationship can be achieved and maintained in a

defined manner. This is unlike the facing of EP-A-0 197 000, in which each panel is positioned by being placed with its rearwardly extending base portion resting on the earth stabilising sheet of geotextile material below.

It is preferred that the overlapping arrangement provides support for the panel above during assembly, possibly with the assistance of wire ties or the like. This will normally mean that the panel above can be installed before the panel to support it has been backfilled with earth, since the panel above does not have to rest on the earth. The panel above may then have an earth stabilising member attached thereto, and the rear of the stabilising member can be buried under earth backfill. Thus the supporting panel can be restrained from forward movement at its upper region by the stabilising member before it is backfilled, rather than by ties connected to a rearwardly extending base portion of the supporting panel, as with EP-A-0 197 000. Subsequently, when the supporting panel is backfilled, earth pressure applied thereto is transferred to the panel above and then to the earth stabilising member. The overlapping arrangement is therefore such as to allow such a transfer of loads.

The upper region or the lower region of the panel may have a first laterally extending bar in front of its upwardly extending bars and a vertically adjacent second laterally extending bar behind the upwardly extending bars. The upwardly extending bars of the vertically adjacent panel may then pass through the mesh openings defined between the first and second bars whilst achieving the desired parallel relationship. Preferably, however, the upwardly extending bars of the upper region or the lower region are prefabricated with a crank such that the bars above and below the crank are offset

and parallel.

It has been proposed in United States Patent No. 4329089 (see Figures 1-4) to provide an arrangement in which a mesh facing panel overlaps with the one below and has a "kink" such that the two panels are parallel. The kink is formed during assembly of the facing, by positioning the new panel at an acute angle to a vertical panel already installed, so that they intersect along a horizontal axis, and then pivotting the new panel to a vertical orientation. This is supposed to form a kink in the new panel, although it is difficult to see how the kink could be reliably and uniformly formed. The preferred crank of the second aspect of the present invention is prefabricated, prior to assembly, rather than during assembly. This ensures a reliable relationship between vertically adjacent panels and gives a facing of neat appearance.

The crank may be formed in the upwardly extending bars of the lower region. In certain preferred arrangements the crank is formed in the upwardly extending bars of the upper region. This is most appropriate where a stabilising member is to be attached at or near the bottom of the panel.

The crank may be to the front or to the rear in the upward direction. Where the crank is provided in the upper region and to the rear, the panel above is advantageously prevented from toppling rearwardly when supported only by the already installed panel during construction. This can also be achieved when the crank is provided in the upwardly extending bars of the lower region, with the crank being either to the front or to the rear in the upward direction.

Preferably, at least one laterally extending bar is omitted from the upper or the lower region of the mesh facing panel. This increases the available

overlap between the upwardly extending bars of the overlapping regions.

The laterally extending mesh bars may be located forwardly of the upwardly extending bars, but preferably they are located to the rear. This ensures that the lateral bars, which will preferably be welded to the upwardly extending bars, do not become dislodged from the facing under earth pressure.

The upper and lower regions of the mesh facing panel are preferably such that in the assembled condition the mesh facing panel above can move downwardly to accommodate earth settlement. With the arrangement including a crank, for example, the panel above may be supported initially with a laterally extending bar thereof at an upward spacing from the crank. Thus, when there is earth settlement the panel can move downwardly relative to the one below, before further movement is prevented by engagement of the lateral bar with the crank. The lower facing panel is therefore not pushed downwardly by the one above and thus any tendency for it to bulge forwardly is significantly reduced. Wedges may be employed between adjacent lateral bars of the two panels during construction to position the panel above at the desired level and then later removed to allow the downward movement to take place if that becomes necessary due to earth settlement.

Although the mesh facing panel of the second aspect of the invention may be generally planar, it is preferably "L" shaped in side elevation, having a front portion and a base portion arranged to extend rearwardly into the earth. This stiffens the panel and makes it easier to handle during construction and less prone to forward bulging in the completed structure. Preferably, the base portion is bent at its rear to form at least one hook. Alternatively,

however, other means may be provided to connect the panel of the second aspect of the invention to an earth stabilising member.

It will be appreciated that the mesh facing panel of the first aspect of the invention may optionally have the features of the mesh facing panel of the second aspect, and vice versa.

The invention also extends to an earth structure having a facing assembled from mesh facing panels as described herein and stabilised by stabilising members as described herein. Further, the invention extends to methods of constructing such structures.

Certain preferred embodiments of the invention will now be described by way of example and with reference to the following schematic drawings, in which:

Figure 1 is a perspective view of a mesh facing panel and stabilising members attached thereto;

Figure 2 is a side elevation view of overlapping portions of vertically adjacent mesh facing panels;

Figure 3 is a view similar to that of Figure 2, but of another embodiment;

Figure 4 is a view similar to that of Figure 2, but of another embodiment;

Figure 5 is a side view of a hook connector mounted on a mesh facing panel;

Figure 6 is an end view on the hook connector, in the direction of arrow VI shown in Figure 5, to an enlarged scale (omitting the panel);

Figure 7 is a side view of a hook of a mesh facing panel showing one type of connection with a stabilising member;

Figure 8 is a view similar to Figure 7, but showing another type of connection;

Figure 9 is a perspective view of the

connection shown in Figure 8;

Figure 10 is a view similar to Figure 7, but showing another type of connection;

Figure 11 is a view similar to Figure 7, but showing another type of connection;

Figures 12A-12H are respective side views showing the construction sequence of an earth structure;

Figure 13 is a side elevation view of a triangular mesh facing panel and a stabilising member attached thereto; and

Figure 14 is a side elevation view of another triangular mesh facing panel and stabilising member;

Figure 15 is a view similar to that of Figure 2, but of another embodiment;

Figure 16 is a view similar to that of Figure 2, but of another embodiment;

Figure 17 is a perspective view of a mesh facing panel with a stabilising member attached thereto; and

Figure 18 is a side view of a mesh facing panel with another form of hook.

Referring to Figure 1, a mesh facing panel 1 comprises a front portion 2 and a base portion 3 extending rearwardly therefrom. The front portion 2 has an upper region 4 for connection to a panel above and a lower region 5 for connection to a panel below. The base portion 3 has at its rear a plurality of hooks 6 to which are attached, at lateral intervals, a plurality of earth stabilising members 7.

The panel 1 is made up of upwardly extending bars 8 to which are welded laterally extending bars 9 to form an array of mesh openings 10. In the upper region 4 some lateral bars 9 are omitted so that the upwardly extending bars 8 project above the uppermost lateral bar 9 by more than the height of

one mesh opening. In this region the upwardly extending bars are formed with a crank 11 to the rear in the upward direction. At the bottom of the mesh facing panel 1 the upwardly extending bars 8 are bent rearwardly to form a junction 12 between the front portion 2 and the base portion 3. In this embodiment the angle of the bend is 65°, corresponding to the angle of the eventual facing to the horizontal. Other angles ranging between 45° and 90° may alternatively be provided. The upwardly extending bars are thus bent to form rearwardly extending bars of the base portion, and are then further bent again at their rear ends to form the hooks 6. In this embodiment the bars are bent through 180° to form forwardly directed hook ends, but other angles are possible, for example 90° to form upwardly directed hook ends.

The left hand part of Figure 1 shows the condition of the mesh facing panel 1 when it is to be used at the top of a facing. The upwardly extending bars 8 are trimmed to the required height and a plurality of hook connectors 13 are mounted on the front portion 2 at the level of the third lateral bar 9 down from the trimmed panel top.

Figure 1 also shows a lining 14 placed behind the panel front portion 2 to prevent erosion of earth backfill through the panel. Such a lining will not normally be necessary if the size of the backfill particles is to be greater than the size of the mesh opening 10, for example where a layer of rock fill is used adjacent to the facing.

The length of the base portion 3 is preferably about 10 to 20 per cent of the length of the front portion, but may be as much as 50 per cent or more.

Figure 2 shows the overlapping arrangement between two panels 1 of the kind in Figure 1. For illustration purposes, the upwardly and laterally

extending bars 8 and 9 of the lower panel are shown without shading, whilst the bars 8 and 9 of the upper panel are shown with shading. In both cases, the lateral bars 9 are welded to the front of the upwardly extending bars 8. Each bar 8 in the upper region 4 of the lower panel passes through a mesh opening 10 in the upper panel, so that below the crank 11 the bar 8 is located forwardly of the lateral bar 9c of the upper panel and above the crank 11 it is located rearwardly of the bars 9a and 9b. In this embodiment each panel is rearwardly displaced from the one below by the amount of the crank 11.

The arrangement ensures that the front portions of the vertically adjacent panels are arranged parallel to each other. Moreover, when the upper panel is lowered down onto the upwardly projecting portions of the bars 8 of the panel below, it is also supported by the panel below. In view of the rearward slope of the front portion 2 of the panel, its tendency will be to topple rearwardly, but this is not permitted by virtue of the engagement of the lateral bars 9a and 9b in front of the upwardly extending bars 8 of the panel below.

A further feature of the connection between vertically adjacent panels is the fact that lateral bar 9b of the upper panel is upwardly spaced from the crank 11 of the lower panel by a spacing 15. The upper panel can thus move downwardly by the length of this spacing during settlement of the earth behind the facing without pushing downwardly on the panel below and causing it to bulge.

It will be appreciated therefore that the connection between overlapping panels achieves alignment of the panels in a parallel condition, support for the upper panel when first positioned, and allows the upper panel subsequently to move

downwardly relative to the lower panel.

The stabilising member shown in Figure 2 is a synthetic geogrid 7, two transverse ribs 16 of which are located in front of the hooks 6. Each geogrid 7 is preferably hooked over four hooks 6 in this embodiment.

The connecting arrangement between vertically adjacent panels shown in Figure 3 differs from that of Figure 2 in that the lateral bars 9 of the panels are located rearwardly of the upwardly extending bars 8. The advantages of the arrangement described above in relation to Figure 2 are achieved by this embodiment. In addition, however, in the arrangement of Figure 3 there is the further advantage that the laterally extending bars 9 are prevented from becoming detached from the front of the panels under earth pressure, whilst the upwardly extending bars 8 are unlikely to suffer from this problem since they are retained at the top and the bottom of each panel. Even the upwardly extending bars 8 which are not connected to stabilising members are retained at the bottom of the panels to a certain extent by virtue of having rearwardly extending continuations forming the base portion 3. Also, in this embodiment the front portions of the vertically adjacent panels are not only parallel to each other, but they are also in the same plane as each other, so that there will be no steps in the facing at the cranks 11.

The connecting arrangement of Figure 4 differs from those of Figures 2 and 3 in that the crank 11 in the upwardly extending bars 8 is to the front in the upward direction. The desired parallel relationship between the panels is achieved. Moreover, downward movement of the upper panel relative to the one below is permitted over the length of the spacing 15 which in this embodiment is

the distance between lateral bar 9c of the upper panel and lateral bar 9d of the lower panel. In this arrangement, in order to assist in ensuring that the upper panel, when newly placed, does not topple rearwardly a wire tie, plastic clips, pieces of string, or the like is used between lateral bar 9a of the upper panel and the upper projection of upwardly extending bar 8 of the lower panel.

A further possible connecting arrangement (not shown) would be for the crank 11 to be to the front in the upward direction (as shown in Figure 4) and the lateral bars 9 of the facing panels to be to the rear of their respective upwardly extending bars 8 (as shown in Figure 3). In such an arrangement wire ties 17 (see Figure 4) may advantageously be used during initial placement of each panel.

In the connecting arrangement of Figure 15 the crank 11 is formed in the upwardly extending bars 8 of the lower region 5 of the mesh panel front portion, rather than the upper region. The crank is to the front in the upward direction. In the connecting arrangement of Figure 16 the crank 11 is also formed in the upwardly extending bars 8 of the lower region 5, the crank being to the rear in the upward direction. In both the Figure 15 and 16 embodiments, the panel above can move downwardly relative to the one below to accommodate earth settlement, as with the other embodiments. Also in Figures 15 and 16, the lateral bars 9 are advantageously behind the upwardly extending bars. The embodiments of Figures 2, 3, 15 and 16 all have the advantage that the panel above is prevented from toppling rearwardly by its interengagement with the one below, without the need for additional ties or the like.

Figures 5 and 6 show further details of the hook connector 13. At its front end the hook

connector has a front connecting portion 18 which is "S" shaped in side elevation and laterally cranked in end elevation. This enables the connecting portion 18 to engage both an upwardly extending bar 8 and a lateral bar 9 of a mesh facing panel 1. At its rear end the hook connector has a hook 19 for attachment of an earth stabilising member. The hook connector shown is bent from a single bar but alternatively a hook connector may be made from a piece of welded mesh bent at both ends to the profile shown in Fig. 5.

Figures 7-11, 17 and 18 show various alternative forms of stabilising member and arrangements for attaching the stabilising members to the hooks 6 of the panels 1. Figure 7 shows a readily deformable geogrid strip which is looped round a laterally extending waler bar 20 received by a plurality of hooks 6. The two portions of the strip 7 above and below the waler bar 20 may be on top of each other or be splayed apart as they extend rearwardly into the earth to provide two full length strips side by side.

Figures 8 and 9 show the use of a stabilising member 7 in the form of a ladder-shaped steel member. In this example a transverse bar 21 of the member is shown engaging two hooks 6.

Figure 17 shows a mesh facing panel 1 to two of the hooks 6 of which are attached respective hooks 40 at the forward end of another form of ladder-shaped stabilising member 41. The hooks 40 are in the form of loops each provided at the forward end of a respective longitudinal bar 42. The end portion 44 of each hook thus lies directly adjacent to the main body of the respective bar 42. The hooks are in a horizontal plane, thereby providing a convenient connecting arrangement with the hooks 6 of the panels 1, which are in a vertical plane. The

stabilising member 41 is formed by two laterally spaced longitudinal bars 42 which are interconnected at longitudinal intervals by lateral bars 21. It is thus similar to that of Figure 9, differing at the forward end and the connection arrangement.

Figure 10 shows a stabilising member 7 in the form of a steel strip formed at intervals along its length with transverse ribs 22 for improving frictional engagement with the earth. The front end of the strip 7 is formed with a vertical aperture, as known for example from GB-A-2 177 140, through which a pin or bolt 23 passes. The pin also passes through two rearwardly extending legs of a "U" shaped lug 24, with the forward end of the strip 7 located between these legs. The lug is engaged on a lateral waler bar 20 which is retained by a plurality of hooks 6 of a mesh facing panel 1.

Figure 11 shows a stabilising member 7 in the form of a strip similar to that of Figure 10, except that at its forward end it is deformed into a hook shape for engagement round the waler bar 20.

In the embodiment of Figure 18, the hook 6 of the mesh facing panel 1 has an end portion 50 which is engaged below a laterally extending bar 9d of the panel. This helps retain the hook in the proper shape under a rearward pulling load applied by a stabilising member. An additional waler bar 51 is attached by welding above the end portion 50 of the hook and below the base portion 3 of the panel, to provide further resistance to straightening of the hook.

Figures 12A-12H show the construction sequence of an earth structure having mesh facing panels and stabilising members as described above. The construction sequence will now be described.

Referring to Figure 12A, a foundation is prepared to provide good alignment of the first

course of panels 1. These panels are placed and secured with a stake 25 to provide the correct inclination. A first layer of stabilising members 7 is attached to the hooks 6 of the panels 1. Referring to Figure 12B, a lining 14 is placed and fixed in position behind the first course of panels or it may be pre-fixed to the panels 1 before assembly.

Earth backfill 26 is placed and compacted, restricting the height 27 of the backfill against the panels 1 to not greater than a certain height, in this case 250mm. Backfill placement is continued up to the level 28 of the second layer of stabilising members, as shown in Figure 12C. Referring to Figure 12D, a second course of panels 1 is engaged on the upper projections of bars 8 of the panels below. The second layer of stabilising members 7 is attached to the hooks 6 at the base of each panel. Slight tension is applied to the stabilising members and their rear ends are pegged by pegs 29 to secure them. With certain types of stabilising member pegging is not necessary as they will stay in place by virtue of their own weight. A stake 25 is additionally used to assist with the correct positioning of the second course of panels 1. These panels are provided with a lining 14 and further backfill is placed on the second layer of stabilising members 7, still restricting the height of backfill against the lower course panels to no more than 250mm, as shown in Figure 12E. At this stage, the second layer of stabilising members 7 are securely retained by being buried in the backfill, so that it is then possible to fill the front of the structure up to no greater than 250mm above the second layer of members 7, as shown in Figure 12F.

The steps described in relation to Figures 12C-12F are repeated for subsequent courses of panels 1

and layers of stabilising member 7. The procedure in relation to the top course of panels 1 will be described with reference to Figure 12G. These panels 1 are shown as trimmed to the desired height, and thus do not have upward projections of the bars 8. Hook connectors 13 are attached to the front portions 2 of the panels 1 at a downward spacing from the trimmed top level, in this example 200-300mm down. A top layer of stabilising members 7 is attached to the hook connectors 13 and are tensioned and pegged by pegs 29. Backfill is then placed in the remaining zone immediately behind the top course of panels 1 and compacted by hand tamping. The completed structure is shown in Figure 12H. It will usually be desired to hydroseed the facing to produce plant growth, so that the mesh of the facing will no longer be visible.

Figure 13 shows a mesh facing panel 1 of triangular cross-section, having a rear portion 30, in addition to a front portion 2 and a base portion 3. The base portion 3 extends rearwardly beyond the rear portion 30 and at its rear end is bent upwardly and forwardly to form a hook 6 behind the rear portion. This can be used for attaching a stabilising member 7 in the various ways described in relation to Figure 2 and Figures 7 to 11. In this example, a lateral bar 20 is provided and the arrangement is similar to that of Figure 7.

Figure 14 shows another triangular panel 1 which differs from that of Figure 13 in that the hook 6 is formed at the rear of the base portion 3 in front of the rear portion 30, so as to be inside the triangle. A lateral bar 20 is provided and the arrangement is suitable for the attachment of certain types of stabilising member, such as strips which are narrower than the width of the mesh openings 20. Alternatively a lug 24 as shown in

Figure 10 may be used.

A variation of the embodiment of Figure 14 is for the hook 6 to be defined simply by a forward bend at the bottom of the rear portion 30. This could for example retain a lateral bar 20. The rear portion could additionally be bent upwardly, as shown in Figure 14.

The panels shown in Figures 13 and 14 are bent from a single sheet of mesh. For ease of transport, it may be preferred for two or three sheets to be used, connected together at the corners of the triangle.

CLAIMS

1. A mesh facing panel for forming a facing of an earth structure stabilised by stabilising members extending rearwardly from the facing into an earth mass, the mesh facing panel comprising a front portion, a base portion arranged to extend rearwardly into the earth, and at least one hook to which at least one said earth stabilising member may be attached.

2. A mesh facing panel as claimed in claim 1, wherein the base portion is bent at its rear to form the at least one hook.

3. A mesh facing panel as claimed in claim 1 or 2, wherein the end of the hook is directed upwardly.

4. A mesh facing panel as claimed in claim 1 or 2, wherein the end of the hook is directed forwardly.

5. A mesh facing panel as claimed in any preceding claim, to which said at least one stabilising member is attached.

6. A mesh facing panel as claimed in claim 5, wherein the stabilising member is hooked directly on to the hook.

7. A mesh facing panel as claimed in claim 5, wherein the stabilising member is attached to the hook via a laterally extending bar received by the hook.

8. A mesh facing panel as claimed in claim 5,

wherein the hook of the panel extends in a vertical plane, and wherein the stabilising member is formed at its forward end with a hook which extends in a horizontal plane, the hook of the panel and the hook of the stabilising member being engaged with each other.

9. A mesh facing panel as claimed in claim 8, wherein the panel has a plurality of laterally spaced hooks engaged with corresponding laterally spaced hooks of the stabilising member.

10. A mesh facing panel as claimed in any preceding claim, and a hook connector to be mounted on the front portion thereof to extend rearwardly therefrom, the hook connector having at its front end means for connection with said front portion and at its rear end a hook for attachment of a said earth stabilising member.

11. A mesh facing panel as claimed in any preceding claim, for assembly with like mesh facing panels to form the facing, the mesh facing panel having an upper region arranged to overlap in the assembled condition with a lower region of a mesh facing panel above, in such a way that the front portions of the mesh facing panels are substantially parallel.

12. An earth structure having a facing assembled from mesh facing panels and stabilised by stabilising members attached to the mesh facing panels and extending rearwardly therefrom into an earth mass, the mesh facing panels and the stabilising members being as claimed in any of claims 5 to 11.

13. A mesh facing panel for assembly with like mesh facing panels to form a facing of an earth structure stabilised by stabilising members extending rearwardly from the facing into an earth mass, the mesh facing panel comprising upwardly and laterally extending mesh bars which define mesh openings, and upper and lower regions, the upper region of the mesh facing panel being arranged to overlap in the assembled condition with the lower region of a mesh facing panel above, with the upwardly extending bars of one of said regions passing through a row of laterally adjacent mesh openings of the other said region, and the mesh facing panel being prefabricated, prior to assembly, such that in the assembled condition it is substantially parallel to the mesh facing panel above.

14. A mesh facing panel as claimed in claim 13, wherein the upwardly extending bars of the upper region or the lower region are prefabricated with a crank such that the bars above and below the crank are offset and parallel.

15. A mesh facing panel as claimed in claim 14, wherein the crank is formed in the upwardly extending bars of the upper region.

16. A mesh facing panel as claimed in claim 14 or 15, wherein the crank is to the rear in the upward direction.

17. A mesh facing panel as claimed in claim 14, 15 or 16, wherein at least one laterally extending bar is omitted from the upper or the lower region of the mesh facing panel.

18. A mesh facing panel as claimed in any of claims 13 to 17, wherein the laterally extending mesh bars are located rearwardly of the upwardly extending mesh bars.

19. A mesh facing panel as claimed in any of claims 13 to 18, wherein the upper and lower regions are such that in the assembled condition the mesh facing panel above can move downwardly to accommodate earth settlement.

20. An earth structure having a facing assembled from mesh facing panels and stabilised by stabilising members attached to the mesh facing panels and extending rearwardly therefrom into an earth mass, the mesh facing panels being as claimed in any of claims 13 to 19.

21. A mesh facing panel substantially as hereinbefore described with reference to any of the accompanying drawings.

22. An earth structure substantially as hereinbefore described with reference to any of the accompanying drawings.

The Patent Office

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Claims searched: 1-12,21 & 22

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.N): E1F FWDJB; E1H HJA, HJB.

Int Cl (Ed.6): E02D

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,P	GB 2283038 A	(Kyokado Engineering) - See fig 5(f)	1-12
X,P	WO 95/06784 A	(The Reinforced Earth Co)	1,3-12
X,P	WO 95/00712 A	(Société Civile des Brevets Henri Vidal)	1,3-12
X	US 4856939 A	(W.K.Hilfiker)	1-12

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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